TITLE OF THE INVENTION
DIAGNOSIS METHOD AND DIAGNOSIS APPARATUS OF PHOTOVOLTAIC POWER SYSTEM

5   BACKGROUND OF THE INVENTION

The present invention relates to a method and an apparatus for diagnosing a photovoltaic power system provided in a house, or the like, in particular to a diagnosis method and a diagnosis apparatus of a photovoltaic power system which diagnoses the

10   normality/abnormality of the output and which, if necessary, diagnoses the cause of the abnormality.

Conventionally, photovoltaic power, which has very little effect on the earths environment and which generates electricity through the usage of solar energy has been considered the most

15   promising clean energy for the future unlike thermal power generation in which fossil fuels undergo combustion and in which large amounts of carbon dioxide are discharged leading to global warming, hydroelectric power generation which has the difficulty of securing installation sites or atomic power generation which has the

20   problem of the disposal of waste, or the like.   Then, in recent years, the spread to residential houses of the photovoltaic power system has expanded in accordance with the introduction of financial assistance from public organizations.

Such a photovoltaic power system comprises a solar battery

25   panel, having a plurality of solar battery cells electrically connected

in series, which is mounted on a roof, or the like, an inverter, which converts the direct current output from the solar battery panel to an alternating current output, wires, which make connections between the solar battery panel and the inverter as well as between the

5   inverter and the loads, and the like.   Then, when the solar rays irradiate the solar battery panel, a photovoltaic conversion is carried out in each solar battery cell and these conversion outputs are collected so as to generate direct current power and, then, this direct current power is converted to alternating current power by

10   the inverter so as to be supplied to the loads.

In order to stably gain a desired electric energy to be supplied to the loads, it is necessary to monitor whether or not the photovoltaic power system operates normally so as to take measures after quickly discovering the cause in the case that it is found that

15   the output is abnormal.   However, a system wherein the diagnosis, of whether or not the operation of the photovoltaic power system is normal, is carried out simply and with a high precision has not yet been constructed.   Though a variety of methods for detecting abnormalities of each component of a solar power system have been

20   conventionally known, there is a problem that, in the case that the output of the photovoltaic power system is abnormal, the work of the discovery of the cause by inspecting each component using such methods takes a long period of time.   In addition, there is a problem that the work of the discovery of the cause cannot be

25   carried out in the case that the output of the system becomes

abnormal in spite of the fact that each component operates normally.

BRIEF SUMMARY OF THE INVENTION

5   One object of the present invention is to provide a diagnosis method and a diagnosis apparatus of photovoltaic power system which can easily and precisely diagnose the normality/abnormality of the output of the photovoltaic power system.

Another object of the present invention is to provide a
10 diagnose method and a diagnosis apparatus of photovoltaic power system which can not only diagnose the normality/abnormality of the output but can also quickly diagnose the cause of the abnormal case.

Still another object of the present invention is to provide a
15 diagnosis method and a diagnosis apparatus of photovoltaic power system which can easily diagnose a cause other than the abnormality of the components.

In a diagnosis method and apparatus according to the first aspect of the invention, a reference output characteristic at the time
20 of normal operation that is obtained in accordance with the installation condition and an output characteristic during actual operation are compared and the comparison result is considered to diagnose the normality/abnormality of the output of the photovoltaic power system.   Therefore, a precise diagnosis result
25 can be quickly gained.

In a diagnosis method and apparatus according to the second aspect of the invention, the reference output characteristic at the time of normal operation is calculated in accordance with the installation condition and the calculated reference output

5   characteristic and the output characteristic which has actually been measured are compared and the comparison result is considered in order to diagnose the normality/abnormality of the output of the photovoltaic power system. Accordingly, the reference output characteristic is calculated in accordance with the installation

10   condition and, therefore, it is not necessary to store, in a memory, a lot of reference output characteristics in accordance with a variety of installation conditions so as to be able to correspond to all installation conditions.

According to the third aspect of the invention, as for the

15   installation condition of the photovoltaic power system according to the first or the second aspect of the invention, site (longitude, latitude, topography, meteorological condition, or the like), direction (16 directions), angle (inclination angle with respect to the ground), configuration (types of solar batteries, number of cells in series,

20   total area of cells (panel area)) are used. Accordingly, precise data of the reference output characteristic can be obtained and, together with that, the diagnosis result becomes precise.

According to the fourth aspect of the present invention, the output characteristic measured in the first or the second aspect of

25   the invention is stored in a memory. Accordingly, a diagnosis

process can be carried out at an arbitrary point of time.

In a diagnosis method and apparatus according to the fifth aspect of the invention, the past output characteristic is preserved and this output characteristic is taken into consideration to

5   diagnose the normality/abnormality of the photovoltaic power system.   Accordingly, a precise diagnosis result can be quickly gained by taking into consideration the effect of the characteristic particular to the photovoltaic power system to be diagnosed.

In a diagnosis method and apparatus according to the sixth

10   aspect of the invention, the reference output characteristic at the time of normal operation is obtained in accordance with the past output characteristic and the obtained reference output characteristic and the output characteristic which has actually been measured are compared so that the comparison result is taken into

15   consideration so as to diagnose the normality/abnormality of the output of the photovoltaic power system.   Accordingly, the reference output characteristic is obtained in accordance with the actual output characteristic of the past and, therefore, the optimal reference output characteristic suitable for each photovoltaic power

20   system can be easily obtained so as to quickly gain a precise diagnosis result.

According to the seventh aspect of the invention, the reference output characteristic is made to be different for each of a plurality of time periods, gained by dividing up a year in the sixth

25   aspect of the invention.   The output characteristic in a photovoltaic

power system is easily influenced by seasonal changes in the
meteorological condition (air temperature, solar radiation time, sun
altitude, or the like).   Therefore, a standard output characteristic
suitable for the meteorological condition is set for each of a plurality

5   of time periods (monthly unit, seasonal unit, or the like) in a year.
Accordingly, the reference output characteristic which is always
optimal throughout the year can be obtained so as to quickly gain a
precise diagnosis result.

In the eighth aspect of the invention, only the output

10   characteristic at the time of the normal case, as a result of a
diagnosis in the sixth or the seventh aspect of the invention, is
reflected in the reference output characteristic for the next time.
Accordingly, the output characteristic of the abnormal case is not
reflected in the reference output characteristic for the next time and,

15   therefore, a reference output characteristic with a high precision
can always be obtained.

In a diagnosis method and apparatus according to the ninth
aspect of the invention, the reference output characteristic used for
the diagnosis of the normality/abnormality of the first photovoltaic

20   power system of to be diagnosed is obtained in accordance with the
output characteristic of the second photovoltaic power system.
Accordingly, even in the first photovoltaic power system which is
newly set, the reference output characteristic thereof is obtained by
considering the output characteristic of the second photovoltaic

25   power system during actual operation which has a similar

installation condition and system characteristic and, therefore, a precise reference output characteristic can easily be obtained.

In a diagnosis method and apparatus according to the tenth aspect of the invention, the comparison result of comparing the reference output characteristic at the time of normal operation with the output characteristic during actual operation, in the first to the ninth aspects of the invention, is considered so as to diagnose the cause of the case where the output is abnormal. Accordingly, the cause of the abnormality can be quickly discovered so as to take immediate measures.

In a diagnosis method and apparatus according to the eleventh aspect of the invention, as for the reference output characteristic and the output characteristic in the first to the tenth aspects of the invention, a direct current voltage, an alternating current voltage, a direct current electric energy, an alternating current electric energy, or the like, are used. Accordingly, a diagnosis can be carried out from multiple points of view and not only the cause due to the abnormality of a component but also other causes can be diagnosed.

In a diagnosis method and apparatus according to the twelfth aspect of the invention, the actual amount of solar radiation during the operation of the photovoltaic power system is measured. Accordingly, data of the amount of solar radiation can be acquired as the data for diagnosis so as to carry out a diagnosis from multiple points of view of a greater number.

The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

5 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG.1 is a schematic diagram showing the first embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power

10 system according to the present invention;

FIG.2 is a flow chart showing an operation procedure of the diagnosis apparatus of photovoltaic power system according to the first embodiment;

FIG.3 is a schematic diagram showing the second

15 embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power system according to the present invention;

FIG.4 is a flow chart showing an operation procedure of the diagnosis apparatus of photovoltaic power system according to the

20 second embodiment;

FIG.5 is a schematic view showing the third embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power system according to the present invention;

25 FIG.6 is a flow chart showing an operation procedure of the

diagnosis apparatus of photovoltaic power system according to the third embodiment;

FIG.7 is a flow chart showing a procedure of a diagnosis process according to the present invention;

5   FIG.8 is a flow chart showing a procedure of a diagnosis process according to the present invention;

FIG.9 is a graph showing the relationship between the reference output characteristic (direct current voltage) at the time of normal operation and the actually measured output

10   characteristic (direct current voltage);

FIG.10 is a graph showing the relationship between the reference output characteristic (direct current voltage) at the time of abnormal operation and the actually measured output characteristic (direct current voltage);

15   FIG.11 is a graph showing the relationship between the reference output characteristic (electric energy) at the time of normal operation and the actually measured output characteristic (electric energy); and

FIG.12 is a graph showing the relationship between the

20   reference output characteristic (electric energy) at the time of abnormal operation and the actually measured output characteristic (electric energy).

DETAILED DESCRIPTION OF THE INVENTION

25   In the following, the present invention is described based on

the drawing showing the embodiments.

(First Embodiment)

FIG.1 is a schematic diagram showing the first embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power system according to the present invention.

A solar battery panel 21 which has a plurality of solar battery cells 20 electrically connected in series is attached to the roof 31 of a house 30 at a predetermined angle with respect to the ground surface. The wire 22 for taking out the output of the solar battery panel 21 is connected to a power adjuster 24 which has an inverter 23 for converting a direct current output to an alternating current output. In addition, the wire 25 for the output from the power adjuster 24 is connected to the load 26, comprising a variety of electric appliances.

When the solar rays irradiate the solar battery panel 21, photovoltaic conversion is carried out in each of the solar battery cells 20 and these conversion outputs are collected so as to generate a direct current power so that this direct current power is converted into an alternating current power by the inverter 23 so that the converted alternating current power is supplied to the load 26.

The diagnosis apparatus of photovoltaic power system according to the first embodiment has a measurement unit 1, a diagnosis unit 2, a diagnosis reference value storage unit 3, a diagnosis factor storage unit 4, a program storage unit 5, a

measurement data memory unit 6, an output unit 7 and a pyrheliometer 8.

The measurement unit 1 measures the value of the output characteristic of the photovoltaic power system during operation. More concretely, the measurement unit 1 chronographically measures the value of the output characteristic (direct current voltage, direct current) before the conversion by the inverter 23 and the output characteristic (alternating current voltage, alternating current, electric power, electric energy) after the conversion. In addition, the measurement unit 1 measures the amount of solar radiation detected by the pyrheliometer 8 installed on the roof 31. Those measured values are stored in the measurement data memory unit 6. Here, each of these measured values is averaged during one segment of one hour so as to be stored in the measurement data memory unit 6. In addition, an abnormal signal of the inverter outputted from the inverter 23 in the case that an abnormality occurs in the inverter 23 is also stored in the measurement data memory unit 6.

The diagnosis reference value storage unit 3 stores diagnosis reference values as a plurality of reference output characteristics obtained in advance in accordance with a variety of installation conditions of the photovoltaic power system. Parameters for these reference output characteristics are the same types of parameters of the characteristic measured in the measurement unit 1 which are stored in the measurement data memory unit 6. In addition, as for

the installation condition of the photovoltaic power system at this time, the installation site (longitude, latitude, topography, meteorological condition, or the like), the installation direction (16 directions), the installation angle (inclination angle with respect to

5   the ground surface), the configuration (types of solar batteries, number of cells in series, total area of cells (panel area)), and the like, are used.

The diagnosis factor storage unit 4 stores a diagnosis factor used at the time of diagnosis of the normality/abnormality and

10   diagnosis of the cause of the abnormality in the photovoltaic power system.   The program storage unit 5 stores an operation program for carrying out these diagnosis processes.

The diagnosis unit 2 reads out the actual characteristic (measured value) gained by the measurement unit 1 from the

15   measurement data memory unit 6 in accordance with the operation program stored in the program storage unit 5 and, at the same time, reads out the diagnosis reference value and the diagnosis factor, respectively, from the diagnosis reference value storage unit 3 and the diagnosis factor storage unit 4 so as to compare the actual

20   measured value which has been read out with the result of multiplication of the diagnostic reference value by the diagnosis factor and, then, diagnoses the normality/abnormality of the output of the photovoltaic power system based on that comparison result and, at the same time, diagnoses the cause of the abnormal case.

25   The output unit 7 outputs and displays the diagnosis result by the

diagnosis unit 2.

Here, for example, in the case that the above measurement unit 1 and the diagnosis unit 2 are configured of a CPU, the diagnosis reference value storage unit 3, the diagnosis factor storage unit 4, the program storage unit 5 and the measurement data memory unit 6 are configured of a hard disc device and the output unit 7 is configured of a liquid crystal display, the diagnosis apparatus of photovoltaic power system according to the first embodiment can be configured of one personal computer for all of the function parts, except for the pyrheliometer 8. Or, the above CPU and the hard disc device may be provided within the power adjuster 24 and the output unit 7 alone may be provided within the house.

Next, the operation of the diagnosis apparatus of photovoltaic power system according to the first embodiment that has the above configuration is described in reference to the flow chart of FIG.2 which shows the procedure thereof.

The values of the characteristic (direct current voltage, direct current, alternating current voltage, alternating current, electric power, electric energy, amount of solar radiation, or the like) of the photovoltaic power system during operation is measured by the measurement unit 1 (Step S1). Then, these measured values are averaged with a unit of one hour and the averaged measured value is stored in the measurement data memory unit 6 (Step S2).

The actual characteristic (measured value) gained by the measurement unit 1 is read out from the measurement data memory unit 6 and, at the same time, the diagnosis reference value and the diagnosis factor are read out from the diagnosis reference value storage unit 3 and the diagnosis factor storage unit 4 (Step S3). Based on these pieces of information which have been read out, the normality/abnormality of the output of the photovoltaic power system is diagnosed and, at the same time, the cause is also diagnosed in the abnormal case (Step S4). Here, in this diagnosis process, in the case that the lower limit diagnosis factor and the upper limit diagnosis factor are, respectively, denoted as r and s, the diagnosis has a result of normal when the condition of the following (1) is satisfied, of which the diagnosis process is described later in detail. The gained diagnosis result is outputted and displayed in the output unit 7 (Step S5).

$$\text{diagnosis reference value} \times r < \text{measured value} < \text{diagnosis reference value} \times s \quad \text{... (1)}$$

(Second Embodiment)

FIG.3 is a schematic diagram showing the second embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power system according to the present invention. Here, in FIG.3, the same or similar elements as in FIG.1 are denoted as the same numerals, of which the descriptions are omitted.

The diagnosis apparatus of photovoltaic power system

according to the second embodiment has a measurement unit 1, a diagnosis unit 2, a diagnosis reference value calculation unit 11, a diagnosis factor storage unit 4, a program storage unit 5, a measurement data memory unit 6, an output unit 7, a

5 pyrheliometer 8 and an input unit 12.

The input unit 12 accepts an external inputs of the installation condition of the photovoltaic power system. The installation condition of the photovoltaic power system at this time includes the installation site (longitude, latitude, topography,

10 meteorological condition, or the like), the installation direction (16 directions), the installation angle (inclination angle with respect to the ground surface), the configuration (types of solar batteries, number of cells in series, total area of cells (panel area)), or the like.

The diagnosis reference value calculation unit 11 calculates

15 the diagnosis reference value as the reference output characteristic at the time of normal operation in accordance with the installation condition of the photovoltaic power system accepted by the input unit 12. These calculated parameters of the reference output characteristic are the same types of parameters of the output

20 characteristic measured by the measurement unit 1 which are stored in the measurement data memory unit 6.

The diagnosis unit 2 reads out the actual characteristic (measured value) gained by the measurement unit 1 from the measurement data memory unit 6 in accordance with the operation

25 program stored in the program storage unit 5 and, at the same time,

reads out the diagnosis factor from the diagnosis factor storage unit 4 so as to compare the actual measured value which has been read out with the result of multiplication of the diagnosis reference value calculated by the diagnosis reference value calculation unit 11 by

5   the read out diagnosis factor, and then diagnoses the normality/abnormality of the output of the photovoltaic power system based on that comparison result and, at the same time, diagnoses the cause of the abnormal case.

Here, for example, in the case that the above measurement

10   unit 1, the diagnosis unit 2 and the diagnosis reference value calculation unit 11 are configured of a CPU, the diagnosis factor storage unit 4, the program storage unit 5 and the measurement data memory unit 6 are configured of a hard disk device, the output unit 7 is configured of a liquid crystal display and the input unit 12

15   is configured of a keyboard, the diagnosis apparatus of photovoltaic power system according to the second embodiment can be configured of one personal computer for all of the function parts, except for the pyrheliometer 8.   Or the above CPU and the hard disc device may be provided within the power adjuster 24 and the

20   output unit 7 alone may be provided within the house.

Next, the operation of the diagnosis apparatus of photovoltaic power system according to the second embodiment that has such a configuration is described in reference to the flow chart of FIG.4 which shows the procedure thereof.

25   The values of the characteristic (direct current voltage,

direct current, alternating current voltage, alternating current, electric power, electric energy, amount of solar radiation, and the like) of the photovoltaic power system during operation are measured by the measurement unit 1 (Step S11). Then, these

5   measured values are averaged with a unit of one hour so that the averaged measured value is stored in the measurement data memory unit 6 (Step S12).

The installation condition of the photovoltaic power system is inputted via the input unit 12 (Step S13). The diagnosis

10   reference value as the reference output characteristic at the time of normal operation is calculated by the diagnosis reference value calculation unit 11 in accordance with the inputted installation condition (Step S14).

The actual characteristic (measured value) gained by the

15   measurement unit 1 is read out from the measurement data memory unit 6 and, at the same time, the diagnosis factor is read out from the diagnosis factor storage unit 4 (Step S15). Based on these pieces of information which have been read out and the calculated diagnosis reference value, the normality/abnormality of

20   the output of the photovoltaic power system is diagnosed and at the same time, in the abnormal case, the cause thereof is also diagnosed (Step S16). Here, the diagnosis has a result of normal when the condition of the above (1) is satisfied and this diagnosis process is later described in detail. The gained diagnosis result is outputted

25   and displayed in the output unit 7 (Step S17).

(Third Embodiment)

FIG.5 is a schematic diagram showing the third embodiment of the case where a diagnosis of a photovoltaic power system is carried out by using a diagnosis apparatus of photovoltaic power system according to the present invention. Here, in FIG.5, the same or similar elements as in FIG.1 or 3 are denoted as the same numerals, of which the descriptions are omitted.

The diagnosis apparatus of photovoltaic power system according to the third embodiment has a measurement unit 1, a diagnosis unit 2, a diagnosis factor storage unit 4, a program storage unit 5, a measurement data memory unit 6, an output unit 7, a pyrheliometer 8, a base value storage part 13 and a correction factor storage unit 14.

The base value storage unit 13 stores twelve types of base values (B) for respective months which become bases for obtaining the diagnosis reference values for respective months as the reference output characteristic. These base values are obtained in advance by taking into the consideration a variety of installation conditions of a photovoltaic power system as described above, in particular the meteorological condition for each month. The correction factor storage part 14 stores the correction factor (v) for correcting the base value in accordance with the value of the actual output characteristic due to the operation of the photovoltaic power system for many years. This correction factor is rewritten by the diagnosis unit 2 in accordance with the value of the output

19

characteristic in the case that the photovoltaic power system has gained a normal output. Here, at the initial year, the correction factor v = 1 is stored. In addition, in the course of operation of the photovoltaic power system for years, the diagnosis factors (r, s)

5   stored in the diagnosis factor storage unit 4 are also rewritten by the diagnosis unit 2. Here, at the initial year, for example, the diagnosis factors r = 0.7, s = 1.3 are stored.

The diagnosis unit 2, in accordance with the operation program stored in the program storage unit 5, obtains the diagnosis

10   reference value by multiplying the base value read out from the base value storage unit 13 by the correction factor read out from the correction factor storage unit 14 and compares the actual measured value at present which has been read out from the measurement data memory unit 6 with the result of multiplication of that

15   obtained diagnosis reference value by the diagnosis factor read out from the diagnosis factor storage unit 4, and then diagnoses the normality/abnormality of the output of the photovoltaic power system based on that comparison result and, at the same time, diagnoses the cause of the abnormal case.

20   Here, for example, in the case that the above measurement unit 1 and the diagnosis unit 2 are configured of a CPU, the diagnosis factor storage unit 4, the program storage unit 5, the measurement data memory unit 6, the base value storage unit 13 and the correction factor storage unit 14 are configured of a hard

25   disk device and the output unit 7 is configured of a liquid crystal

display, the diagnosis apparatus of photovoltaic power system according to the third embodiment can be configured of one personal computer for all of the function parts, except for the pyrheliometer 8. Or the above CPU and the hard disc device may be provided within the power adjuster 24 and the output unit 7 alone may be provided within the house.

Next, the operation of the diagnosis apparatus of photovoltaic power system according to the third embodiment that has such a configuration is described in reference to the flow chart of FIG.6 which shows the procedure thereof.

The values of the characteristic (direct current voltage, direct current, alternating current voltage, alternating current, electric power, electric energy, amount of solar radiation, and the like) of the photovoltaic power system during operation are measured by the measurement unit 1 (Step S21). Then, these measured values are averaged with a unit of one hour so that the averaged measured value is stored in the measurement data memory unit 6 (Step S22).

The base value and the correction factor are respectively read out from the base value storage unit 13 and the correction factor storage unit 14 (Step S23) and they are multiplied with each other so as to obtain a diagnosis reference value as the reference output characteristic (Step S24). The actual measured value gained by the measurement unit 1 is read out from the measured data memory unit 6 and, at the same time, the diagnosis factor is

read out from the diagnosis factor storage unit 4 (Step S25). Based on these pieces of information which have read out and the obtained diagnosis reference value, the normality/abnormality of the output of the photovoltaic power system is diagnosed and, at the same time,

5   in the abnormal case, the cause thereof is diagnosed (Step S26). At this time, the diagnosis has a result of normal when the condition of the above (1) is satisfied while the diagnosis has a result of abnormal in other cases. Here, the diagnosis process of the cause is later described in detail.

10   Whether or not the diagnosis result is normal is determined (Step S27) and, in the abnormal case (S27: NO), the output unit 7 outputs and makes a display to that effect (Step S31) so as to complete the process as it is.

On the other hand, in the normal case (S27: YES), after the

15   output unit 7 outputs and makes a display to that effect (Step S28), the correction factor is changed in accordance with the actual measured value at that time so that the new correction factor is written into the correction factor storage unit 14 (Step S29) and, at the same time, the diagnosis factor is also changed and the new

20   diagnosis factor is written into the diagnosis factor storage unit 4 (Step S30).

In the following, a concrete example of this diagnosis process in the third embodiment is described. Here, the output characteristic which becomes the diagnosis reference is assumed to

25   be electric energy, the diagnosis process in January of every year

(for three years) is described.

<First Year>

The base value B = 100 kWh is stored in the base value storage unit 13, the correction factor v = 1 is stored in the correction factor storage unit 14, the lower limit diagnosis factor r = 0.7 and the upper limit diagnosis factor s = 1.3 are stored in the diagnosis factor storage unit 4, respectively, as initial values. By multiplying this base value B = 100 kWh by the correction factor v = 1, the diagnosis reference value 100 kWh is obtained (S24). The actual measured value is assumed to be 120 kWh. In this case, the condition of the above (1) is satisfied as shown in (2) below and, therefore, the electric energy is diagnosed as normal (S26).

diagnosis reference value (100) $\times$ r (0.7) < actual measured value (120) < diagnosis reference value (100) $\times$ s (1.3)   ... (2)

Since the diagnosis has the result of normal (S27: YES), "normal" is outputted and displayed in the output unit 7 (S28). In addition, the correction factor v of the correction factor storage unit 14 is changed (S29). More concretely, the average value 1.1 between actual measured value (120) $\div$ base value (100) = 1.2 and present v = 1 is written into the correction factor storage unit 14 as a new correction factor v. In addition, the diagnosis factors r, s of the diagnosis factor storage unit 4 are changed (S30). More concretely, since the actual measured value is reflected for the correction factor, the diagnosis factors r, s are both made closer to 1 by 0.01 so as to be r = 0.71, s = 1.29, which are written into the

diagnosis factor storage unit 4.

<Second Year>

At this point in time, the base value B = 100 kWh is stored in the base value storage unit 13, the correction factor v = 1.1 is stored in the correction factor storage unit 14, the lower limit diagnosis factor r = 0.71 and the upper limit diagnosis factor s = 1.29 are stored in the diagnosis factor storage unit 4, respectively. By multiplying this base value B = 100 kWh by the correction factor v =1.1, the diagnosis reference value 110 kWh is obtained (S24). The actual measured value is assumed to be 77 kWh. In this case, the condition of the above (1) is not satisfied as the following (3) and, therefore, the electric energy is diagnosed as abnormal (S26).

actual measured value (77) < diagnosis reference value (110) × r (0.71)   ... (3)

Since the diagnosis has the result of abnormal (S27: NO), "abnormal" is outputted and displayed in the output unit 7 (S31). Here, since the abnormality is obtained, the correction factor and the diagnosis factor are not changed.

<Third Year>

At this point in time, in the same manner as in the second year, the base value B = 100 kWh is stored in the base value storage unit 13, the correction factor v = 1.1 is stored in the correction factor storage unit 14, the lower limit diagnosis factor r = 0.71 and the upper diagnosis factor s = 1.29 are stored in the diagnosis factor storage unit 4, respectively. By multiplying this base value B =

100 kWh by the correction factor v = 1.1, the diagnosis reference

value 110 kWh is obtained (S24).   The actual measured value is

assumed to be 130 kWh.   In this case, the condition of the above (1)

is satisfied as in the following (4) and, therefore, the electric energy

5   is diagnosed as normal (S26).

diagnosis reference value (110) $\times$ r (0.71) < actual

measured value (130) < diagnosis reference value (110) $\times$ s (1.29)

... (4)

Since the diagnosis has the result of normal (S27: YES),

10   "normal" is outputted and displayed in the output unit 7 (S28).

In addition, the correction factor v of the correction factor storage

unit 14 is changed (S29).   More concretely, the average value 1.2

between actual measured value (130) $\div$ base value (100) = 1.3 and

present v = 1.1 is written into the correction factor storage unit 14

15   as a new correction factor v.   In addition, the diagnosis factors r, s

of the diagnosis factor storage unit 4 are changed (S30).   More

concretely, since the actual measured value is reflected for the

correction factor, the diagnosis factors r, s are both further made

closer to 1 by 0.01 so as to be r = 0.72, s = 1.28, which are written

20   into the diagnosis factor storage unit 4.

Here, though in this third embodiment the base value stored

in the base value storage unit 13 is assumed not to change, it is

preferable to change the base value to correspond to changes in the

surrounding environment in the case that those changes are large,

25   such as the construction of a large building in the neighborhood.

At this time, as for the changed base value, a simulation result which is obtained again after taking respective conditions into consideration in the same manner as in the case of the initial value may be adopted or the actual measured value after the change of

5   the environment may be adopted.   In addition, though in the concrete example of the third embodiment the base value, the diagnosis reference value, or the like, are made to be different for every month, that period may be arbitrarily set and those values may be made different for each season (spring, summer, autumn

10   and winter).

In addition, the value of the output characteristic actually measured for each month (or for each season) and the average value of the measurement result of the output characteristic for the same month (or for the same season) over the past several years are

15   simply compared and, based on this comparison result, a diagnosis to determine normality/abnormality of a photovoltaic power system and to find the cause of the abnormality may be carried out.

Next, the process for diagnosing the normality/abnormality of the output of a photovoltaic power system in the above described

20   first, second and third embodiments, as well as the cause of the abnormality, is described in detail.   FIG.7 and 8 are flow charts showing the operation procedure of that diagnosis process, that is to say, the sub-routines of S4 of FIG. 2, S16 of FIG.4 and S26 of FIG.6.

With respect to each measured value (direct current voltage,

25   direct current, alternating current voltage, alternating current,

electric power, electric energy) of the actual output characteristic

and each diagnosis reference value (direct current voltage, direct

current, alternating current voltage, alternating current, electric

power, electric energy) as the reference output characteristic,

5   whether or not the condition in the following (5) is satisfied is

determined (Step S41).   Here, p, q are constants of diagnosis

factors stored in the diagnosis factor storage unit 4 wherein, for

example, $p = 2$, $q = 0.5$.

diagnosis reference value $\times$ p < measured value or diagnosis

10   reference value $\times$ q > measured value   ... (5)

In the case that the condition (5) is satisfied (S41: YES), the

measurement is determined to be abnormal (Step S 51) and no

diagnosis process is carried out.   On the other hand, in the case

that the condition (5) is not satisfied (S41: NO), whether or not the

15   condition of the above (1) is satisfied is determined for each

measured value and for each diagnosis reference value (Step S42).

In the case that the condition (1) is satisfied (S42: YES), the

photovoltaic power system is diagnosed as normal (Step S52).   On

the other hand, in the case that the condition (1) is not satisfied

20   (S42: NO), the following process for diagnosing the cause of the

abnormality is carried out.

FIG.9 and 10 are graphs showing the relationships between

the measured value of the direct current voltage and the diagnosis

reference value thereof in a particular installed photovoltaic power

25   system (installation site: within Osaka city limits, installation

direction: facing to the west, installation angle: 30 degrees,

maximum electric power: 3 kW) in June.   In the graph of FIG.9,

since the measured value and the diagnosis reference value satisfy

the condition (1), the diagnosis has the result of normal.   On the

5   other hand, in the graph of FIG.10, since the above values satisfy

neither of the conditions of (5) nor (1), the diagnosis has the result

of abnormal.

FIG.11 and 12 are graphs showing the relationships between

the measured value of the electric energy and the diagnosis

10   reference value thereof in the photovoltaic power system installed

under the same condition as the above.   In the graph of FIG.11,

since the measured value and the diagnosis reference value satisfy

the condition (1), the diagnosis has the result of normal.   On the

other hand, in the graph of FIG.12, since the above values do not

15   satisfy the condition (5) and do not satisfy the condition (1) during

the time period from 13:00 to 16:00, the diagnosis has the result of

abnormal.

Whether or not an abnormal signal of the inverter exists is

determined (Step S43) and, in the case of such existence (S43: YES),

20   the diagnosis has the result of an abnormality of the inverter 23

(Step S53).   In addition, the conversion efficiency of the inverter (=

alternating current electric energy/direct current electric energy) is

obtained so that whether or not this value is within the range of 0.8

to 0.97 is determined (Step S44).   In the case that it is not in that

25   range (S44: NO), the diagnosis is an abnormality of the inverter 23

(S53).

Whether or not the direct current voltage is abnormal is determined (Step S45) and, in the abnormal case (S45: YES), the diagnosis has the result of an abnormal equipment (more concretely,

5   abnormality in the solar battery panel 21 or in the wire 22 for taking out the output) (Step S54).   A diagnosis example of this case corresponds to FIG.10.   Whether or not the alternating current voltage is abnormal is determined (Step S46) and, in the abnormal case (S46: YES), the diagnosis has the result of an abnormal system

10   (Step S55).   In the case that the alternating current voltage exceeds a predetermined range (101 $\pm$ 6V), it is legally prescribed that the adjustment must be carried out within the power adjuster 24 so that the diagnosis has the result of abnormality due to this adjustment function.

15   The alternating current electric energy of the reference output characteristic and the actually measured alternating current electric energy are compared (Step S47).   In the case that the latter is larger than the former (S47: YES), since the measured electric energy is larger than the reference electric energy, the system

20   doesn't have any problems and the diagnosis has a result of no abnormality (Step S56).

With respect to the alternating current electric energy of the reference output characteristic and the actually measured alternating current electric energy, whether or not there is a time

25   zone where the two are equal is determined (Step S48).   In the case

29

that this time zone exists (S48: YES), the diagnosis has a result of abnormal of the output decrease due to the shadows of buildings, trees, or the like, which exist around the house (Step S57). A diagnosis example of this case corresponds to FIG.12. In the

5   example, as shown in FIG.12, the reference electric energy and the measured electric energy are almost equal in the morning and in the afternoon (between 13:00 and 16:00) the measured electric energy is significantly lower than the reference electric energy and, therefore, it is considered that the output is lowered due to the

10   existence of shadows of blocking objects such as buildings or trees to the west of this house, with reference to the position of the sun.

The reference amount of solar radiation and the actually measured amount of solar radiation are compared (Step S49). In the case that the former is larger than the latter (S49: YES), the

15   diagnosis has a result of abnormal of the output decrease due to shadows (S57). In the other case (S49: NO), the diagnosis has a result of inferior equipment (Step S58). As for the inferior equipment, a slightly smaller output of the installed solar battery panel 21 than the standard value, the lengthening of wires leading

20   to increase in the resistance value, or the like, are cited.

Here, the above described diagnosis reference of the normality/abnormality in the process, as well as the diagnosis reference of the cause of abnormality, serve as examples and other diagnosis references may, of course, be used.

25   In addition, the diagnosis apparatus in the first to the third

embodiments may be built in, in advance, in the installed

photovoltaic power system or may be attached to the photovoltaic

power system through connection at the time of the diagnosis

process.   Furthermore, though a photovoltaic power system

5   wherein the output from the power adjuster 24 is directly supplied

to the load 26 is described in the first to the third embodiments, the

present invention is, of course, not limited to this but, rather, can be

applied to a photovoltaic power system which is systematically

connected to a commercial power source.

10   Here, though in a newly installed photovoltaic power system,

the above described diagnosis reference values in the first and

second embodiments, as well as the base value in the third

embodiment, are obtained by considering the installation condition,

in the case that another photovoltaic power system exists in the

15   vicinity wherein this condition is the same, or similar, it is possible

to utilize the diagnosis reference value, the base value or the actual

output characteristic (measured value) as it is, or after a fine

adjustment, for the above diagnosis reference value and for the

above base value.   In addition, in the case that such a photovoltaic

20   power system does not exist in the vicinity, it is also possible to

acquire such pieces of information from a photovoltaic power system

during operation which is installed in a remote location.

As described above, in the present invention, the reference

output characteristic at the time of normal operation which is

25   obtained based on the installation condition and the actual output

characteristic during operation are compared and, based on this comparison result, the normality/abnormality of the output is diagnosed and, at the same time, the cause of the case of abnormal output is also diagnosed if necessary and, therefore, precise results

5   of these diagnoses can be quickly gained.

In addition, in the present invention, the reference output characteristic at the time of normal operation is calculated based on the installation condition and the calculated reference output characteristic and the actually measured output characteristic are

10 compared so that, based on this comparison result, the normality/abnormality of the output is diagnosed and, at the same time, the cause of the case of abnormal output is also diagnosed if necessary and, thereby, precise results of these diagnoses can be gained and since the reference output characteristic is calculated

15 according to the installation condition, it is not necessary to store many reference output characteristics in a memory so that it becomes possible to correspond to a variety of installation conditions.

In addition, in the present invention, as for the installation

20 condition of a photovoltaic power system, at least the site, the direction, the angle and the configuration are used and, therefore, precise data of reference output characteristic can be obtained and, as a result, it becomes possible to gain a precise diagnosis result.

In addition, in the present invention, the measured output

25 characteristic is stored in a memory and, therefore, a diagnosis

process can be carried out at an arbitrary point in time.

In addition, in the present invention, since the past output characteristic is stored so that the past output characteristic is taken into consideration to diagnose the normality/abnormality of the output of the photovoltaic power system and, at the same time, to diagnose the cause of the case of abnormal output if necessary, it becomes possible to gain a precise diagnosis result which reflects the effect of the characteristic particular to the photovoltaic power system to be diagnosed.

In addition, in the present invention, the reference output characteristic at the time of normal operation is obtained in accordance with the past output characteristic and the obtained reference output characteristic and the actually measured output characteristic are compared so that this comparison result is taken into consideration in order to diagnose the normality/abnormality of the output and, therefore, since the reference output characteristic is obtained in accordance with the past actual output characteristic, the optimal reference output characteristic suitable for each photovoltaic power system can easily be obtained so that it becomes possible to quickly gain a precise diagnosis result.

In addition, in the present invention, since reference output characteristics different for each of the plurality of periods of time gained by dividing a year are set by taking the seasonal changes in the meteorological condition into consideration, the reference output characteristic that is always optimal throughout the year can be

obtained so that it becomes possible to quickly gain a precise diagnosis result.

In addition, in the present invention, in the case of abnormal output characteristic, this output characteristic is not reflected in

5 the subsequent reference output characteristic and only in the case of normal output characteristic is this output characteristic in the subsequent reference output characteristic and, therefore, it becomes possible to obtain a reference output characteristic with a high precision in a chronological manner.

10 In addition, in the present invention, since at least, direct current voltage, alternating current voltage, direct current electric energy, alternating current electric energy, are used as the reference output characteristic and the output characteristic, diagnosis can be carried out from multiple aspects so that it

15 becomes possible to correctly diagnose not only the cause of the abnormal component but also to correctly diagnose other causes.

In addition, in the present invention, since the actual amount of solar radiation is measured, the data of the amount of solar radiation can be acquired as the data for diagnosis so as to

20 carry out a diagnosis from multiple aspects of a greater number.

Furthermore, in the present invention, since the reference output characteristic is acquired from another photovoltaic power system of which the installation condition and system characteristic are similar, it becomes possible to more easily obtain a precise

25 reference output characteristic.

As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims

5   rather than by the description preceding them, and all change that fall within metes and bounds of the claims, or equivalence of such metes and bounds thereof are therefore intended to be embraced by the claims.